USAELRDL Technical Report 2359

SOLID-STATE MICROMINIATURE CIRCUITRY FOR THE RADIOSONDE

M. Robert Miller

June 1963

UNITED STATES ARMY
ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY
FORT MONMOUTH, N.J.

U. S. ARMY ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY
FORT MONMOUTH, NEW JERSEY

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SOLID-STATE MICROMINIATURE CIRCUITRY
FOR THE RADIOSONDE

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ABSTRACT

This report describes the manner in which functions performed in the present radiosonde by means of tube circuits and mechanical clocks and switches can be performed by integrated circuits. The use of integrated circuitry, coupled with work now being done to develop a tunnel diode oscillator for the transmitter, should result in a size reduction of 95% or greater, as well as considerable savings in weight and power consumption.

The rocket version of the radiosonde is an application to which integrated circuitry is ideally suited if digital type circuits are used.

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CONTENTS

FIGURES

SOLID-STATE MICROMINIATURE CIRCUITRY FOR THE RADIOSONDE

INTRODUCTION

The present radiosonde is an instrument which is carried aloft by a balloon and radios information on atmospheric temperature, humidity, and barometric pressure back to a ground receiving station. This is done while the balloon is being tracked for wind velocity information. This balloon-borne equipment is, however, limited to a maximum altitude of 150,000 feet, and in order to get higher altitude measurements an alternate system is being considered. In this system, the radiosonde is carried up by a rocket with measurements made as it parachutes back down. A rocket of this type will require a substantial reduction in the size and weight of the instrument.

This report describes a system for performing the functions of timing, measurement, and modulation using microminiature integrated circuitry. The use of integrated circuitry, coupled with work now being done to develop a tunnel diode oscillator for the transmitter, should result in a size reduction of 95% or greater.

DISCUSSION

General

The radiosonde transmitter is modulated by negative pulses. The repetition rate of these pulses is related to the resistance of the temperature or humidity sensor or reference resistor. These resistors, the temperature sensor (thermistor), humidity sensor, and reference resistor, must be switched into the measuring circuit one at a time and left on for a period long enough to make a measurement before the next one is switched into the circuit.

The required functions, then, are timing, switching, and modulation. At present the timing is done by a mechanical clock motor and switching by a commutator. The modulating circuit is a tube type blocking oscillator. These same functions can be performed by transistor circuits which could be produced as integrated circuits.

Timing

A period of about 2 seconds is desired as the "on" time for each resistor to be in the measuring circuit. In order to achieve a period this long with an astable multivibrator (Fig. 1) the time constant, determined largely by R_b and C, must be very large. It is desirable to limit C because large values of capacitance become physically very large. Therefore, the long R-C time constant must be achieved by making R large.

R is limited by the current requirements of the transistor. The current through R_b must be sufficient to drive the transistor into saturation. These requirements can all be met if "micropower" transistors, which only recently have become available, are used.

The transistors used in the initial circuit were similar to the 2N929 and had an h_{FE} of 40 at $I_C = 5\mu A$. Since the transistor has sufficient gain, even at ultra-low current levels, large resistors can be used. In this circuit, the values used were:

$$C = .1\mu f \ , \ R_b = 10M \ , \ R_L = 470k \ , \ V_{CC} = 3 \ V$$

and this resulted in a period of about 1.5 sec. This period can be changed over a wide range by changes in capacitance. Letting $C = 8\mu f$ in this circuit produced a period of about 2 min. This circuit could be produced in integrated form except for the large capacitors. Outboard capacitors of the proper value need not be too large because of the low working voltage.

Switching

The timing signal consists of a square wave that has equal on and off periods of 2 sec each. This waveform appears at both of the outputs with a 180° phase difference between them. The negative pulse from one of these outputs is used to drive a bistable multivibrator to give a total of four states as in Fig. 2. These signals are sent to four NOR gates so that three are at low potential and one is high at any time. This is illustrated in Fig. 3.

Modulation

The modulation is done by an astable multivibrator (Fig.4) similar to the timing circuit. This multivibrator, however, is not symmetrical. One pulse is very short and fixed while the other is long and is controlled by the sensing resistors. The sensing resistors are inserted in the base of one of the transistors, and variations in this resistance vary the time required to charge the capacitance. Two reference resistors are used since four states are available. One is a high resistance and the other is low, providing calibration at both ends. The output then is a series of short pulses whose repetition rate depends on the resistance in the base circuit at that time. This is the type of modulation generally used in the radiosonde (Fig.5).

This output can be used to modulate the tunnel diode oscillator (Fig.6) in any of several ways. A transistor in the oscillator power supply can turn off the oscillator completely for the duration of each pulse or reduce the input voltage and thereby change the oscillator frequency.

CONCLUSIONS

The rocket version of the radiosonde is an application to which integrated circuitry is ideally suited if digital type circuits are used. The savings in size, weight, and power are evident advantages.

Also, the fact that long-period timing circuits are possible with transistors operating at very-low power levels may be of interest in other applications.

The power requirements of these circuits are very small, on the order of a few milliwatts. Therefore, the battery requirements in the radiosonde will be determined largely by the tunnel diode oscillator.

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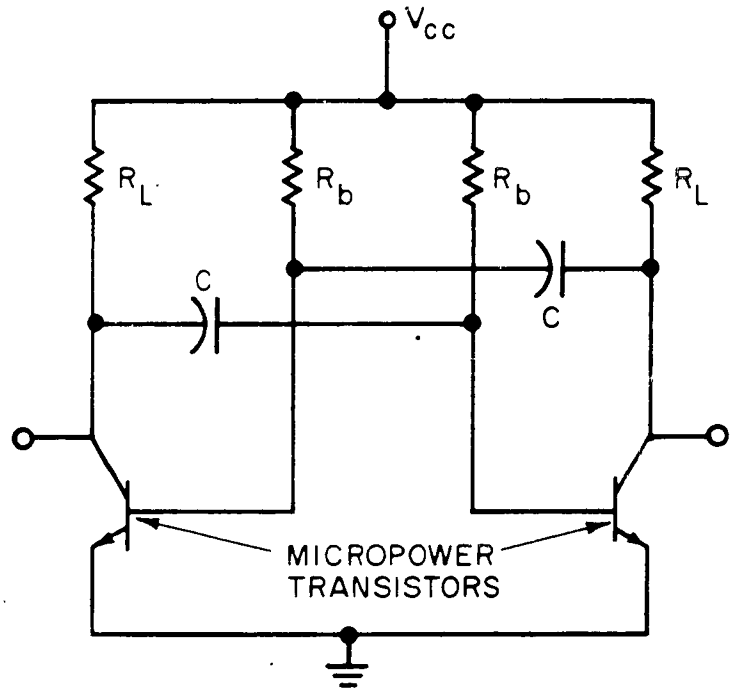
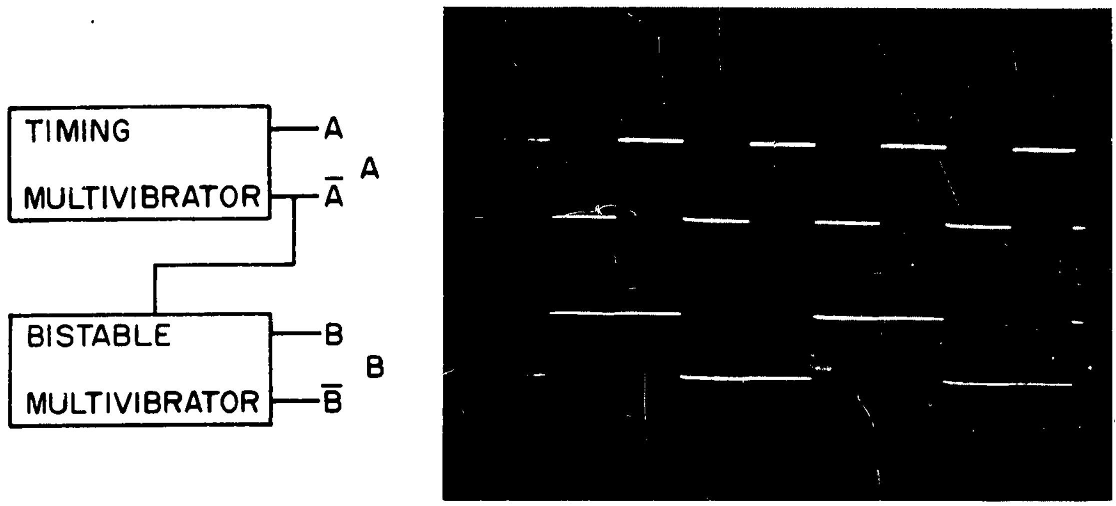
1. Engineering Report - "Radiosonde Set AN/AMQ-9 ( )" - by Arnold C. Peterson, 15 Jan 1958, Report No. E-1223.

2. "L-Band Tunnel Diode Oscillator" - Quarterly Progress Reports, Nos. 1 and 2, 1 June-31 Aug, 1 Sept-30 Nov, 1962. Contract No.DA 36-039 SC-90773.

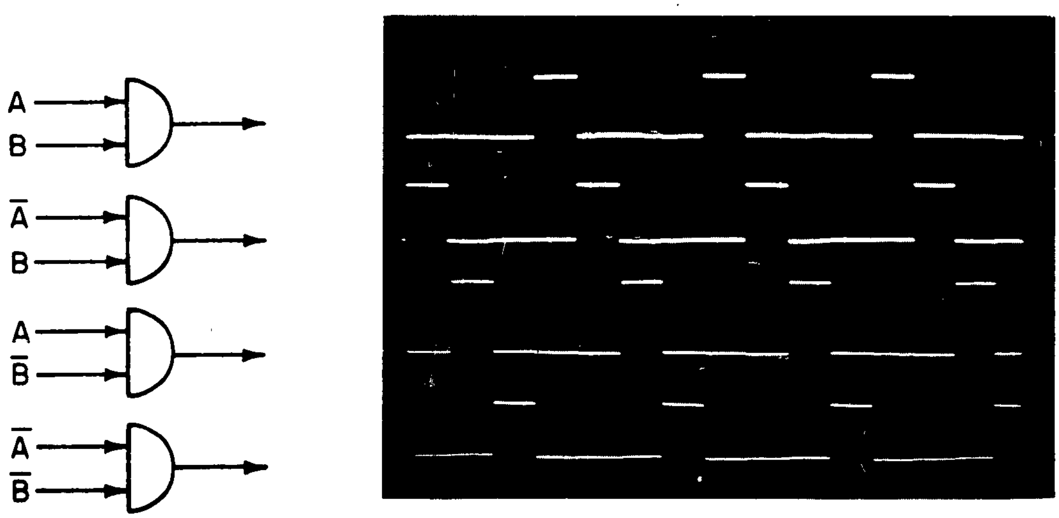


TIMING MULTIVIBRATOR

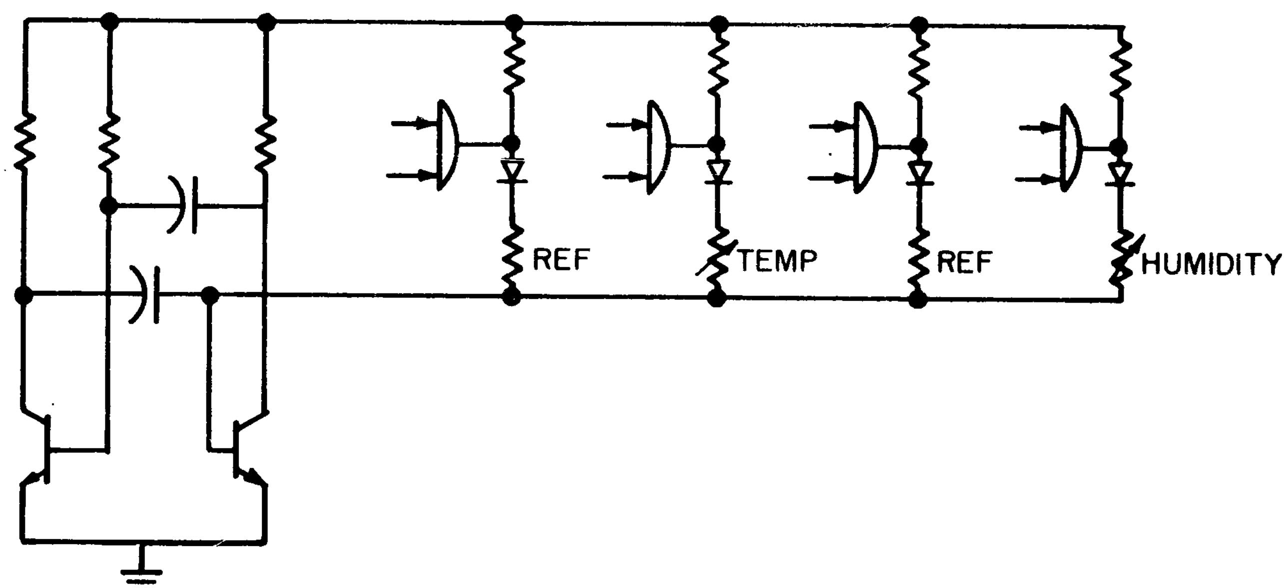
FIG. 1



TIMING PULSES
FIG. 2

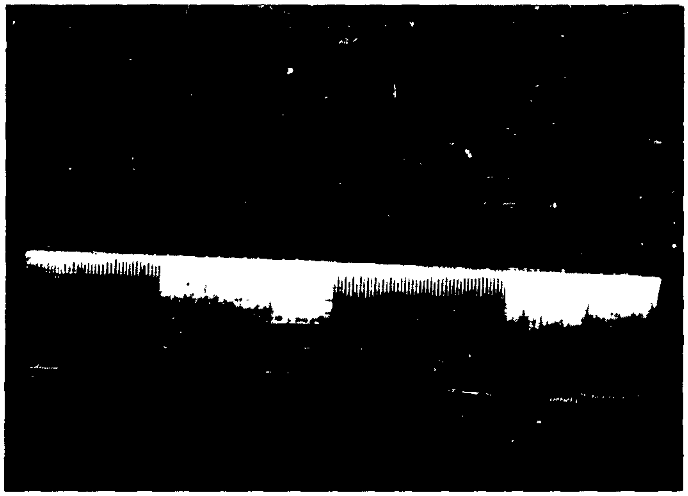


GATING SEQUENCE
FIG. 3

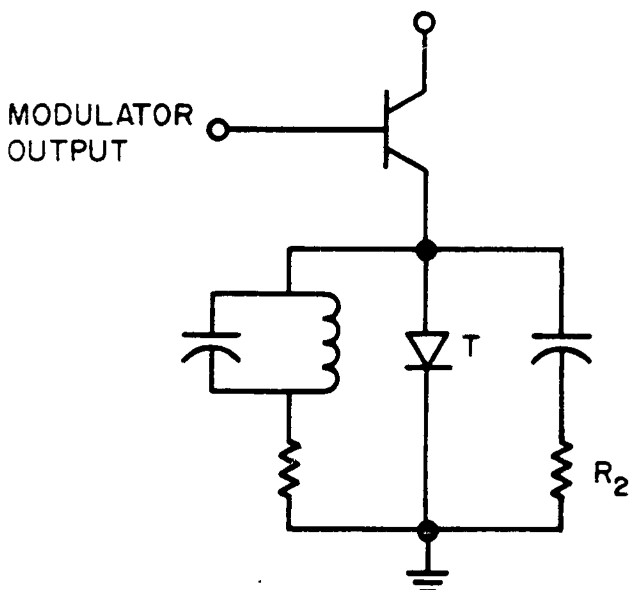


MEASURING MULTIVIBRATOR

FIG. 4



MODULATOR OUTPUT
FIG. 5



TUNNEL DIODE OSCILLATOR
FIG. 6

M-62-554

.137"

INTEGRATED GATING CIRCUIT
FIG. 7

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1. Radiosonde
2. Micropower Transistors
3. Integrated Circuitry

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